LAND RECLAMATION AND ECOLOGICAL EQUILIBRIA OF POTENTIAL PESTS AMONG SOIL FAUNA AT DIHMIT FARM, ASWAN DESERT, EGYPT

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ABSTRACT

An area of 5-7 acres at Dihmit, 60 km South East of Aswan city, was reclaimed since 1987, for desert agriculture . The most important crops are carcade' (Hibiscus sabdariffa), Casuarina sp. and Lawsonia inermis, irrigated by underground water. Soil fauna were collected by the pitfall trap method during the period from Nov. 1989 to Jan. 1991. Data were treated by advanced statistical methods: correspondence analysis and ascending hierarchic classification. The faunal groups recorded are Odonata, Gryllidae, Dermaptera, Lepidoptera, Formicidae, Coleoptera and Aranidae. Trophic groups are herbivores (96%), detritivores (2%) and carnivores (2%). When a natural ecosystem, a desert, is converted to agriculture (land reclamation and creation of agro-ecosystem) by irrigation, this will induce perturbations in the balance between functional (trophic)groups of soil fauna with an increase in herbivores (potential agricultural pests) and a decrease in carnivores (predators or herbivore, natural enemies).Herbivores were present during all the sampling period, while detritivores and carnivores appeared in very small numbers only at the end of the sampling period. Also, at the end of the sampling period, absolute numbers of herbivores were markedly reduced.

INTRODUCTION

Reclamation of a desert area for agriculture and the continuous irrigation of cultivated crops by water, produces a profound effect on the physical properties as well as the biological components of the soil of that area.

Consequently, a state of disequilibrium between the functional (trophic)groups; herbivores, detritivores, and carnivores; of soil fauna of that area may occur. As a result, the number of herbivores may increase while the number of carnivores(herbivorel natural enemies) may decrease. This will open the for the outbreak of potential agricultural pests.

The aim of the present study is to investigate the status of herbivores and their possibilities to be agricultural pests in a newly reclaimed farm at Dihmit, Aswan area.

MATERIAL AND METHODS

Dihmit farm is located in the Eastern Desert of Egypt, about 60 km south east of Aswan city (Fig. 1). The area is a completely barren and rainless flat sandstone desert, with rainfall occurring at the rate of once every three years (the last rain event was in October 1988). The nearest plants (a few *Acacia* trees) occur in the Umm Hebal pass some 10 km away. The area is separated from Lake Nasser by a series of ridges at 20-50 m elevation. The land was reclaimed during 1987 and used for cultivation. This farm irrigated by underground water. Its area is about 5-7 acres and it is managed by the Aswan High Dam Lake Authority. The most important crops are carcade (*Hibiscus sabdariffa*), *Casuarina* sp., and *Lawsonia inermis.*

The area is part of the hyper-arid province of Egypt (UNESCO, 1977) and receives virtually no rainfall. The climate is extremely harsh. Winter is comparatively mild but maximum temperature exceeds 40°C from March to October. Some meteorological data from the nearest station (Aswan city) are given in Table (1).

Soil fauna was investigated by the pitfall trap method as described by SOUTHWOOD (1978) and SLINGSBY and COOK (1986). Catches of

Table (1) Climatological Normals of Aswan over the period (1960-1975).

	Temperature C			Rainfall (mm)	Relative Humidity	Evaporation Per day mms
Month	Max	Min.	Mean	Total	%	Piche
January	23.5	8.1	15.5	Tr.	35	10.4
February	26.2	9.6	17.8	Tr.	26	13.2
March	30.5	13.0	22.0	Tr.	18	17.3
April	35.3	17.9	26.9	0.5	14	21.0
May	38.7	21.4	30.5	Tr.	13	24.7
June	41.8	24.3	33.4	0.0	13	27.3
July	41.1	24.8	33.5	0.0	16	26.0
August	41.0	24.8	33.3	Tr.	18	24.9
September	39.5	22.6	31.1	0.0	20	23.3
October	36.4	19.6	27.9	Tr.	22	20.2
November	29.8	14.6	21.8	0.1	33	14.5
December	25.0	9.7	17.0	0.1	37	11.3
Total	-	-	-	0.7	-	-
annual/mean	34.1	17.4	25.9	-	22	19.5

pitfall traps are a measure of species relative importance on the surface of the soil (GREENSLADE and GREENSLADE, 1983) to which the term activity-density (MIKHAIL and SOBHY, 1992a) is given in the present study.

Samples were collected monthly from Nov. 1989 to Jan. 1991 with few gaps in between. Ten pitfall traps were used in each sampling month.

Data obtained in the present study were treated by advanced statistical methods: correspondence analysis (CA) and ascending hierarchic classification (AHC). Detailed explanation of (CA) can be found in HOWARD (1992) and for (AHC) in ROUX (1985). The computer calculations for (CA) and (AHC) were carried out at Cairo University using DATAVISION program 1.2 (ROUX, 1987) developed for APPLE IIe in BASIC.

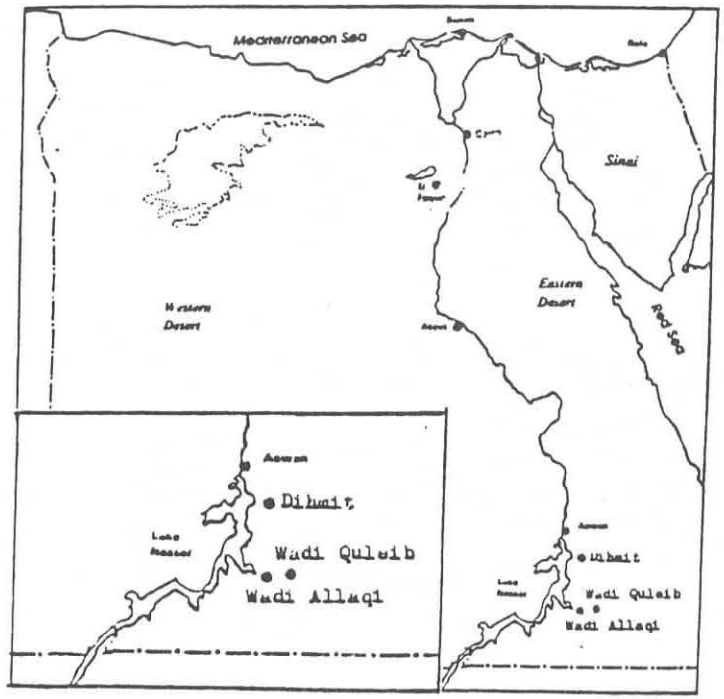

Fig. (1) Location map of Dihmit farm.

Data of activity-density (AD), biomass (BM) and absolute and relative frequency (AF and RF)) , were synthesized into Absolute Importance Value (AIV) and Relative Importance Value (RIV)) as suggested by GHABBOUR AND SHAKIR (1980). The absolute importance value (AIV) was calculated as log (ADXBMXAF). The Relative Importance Value (RIV) was calculated as %AD+%BM+%RF

RESULTS

The soil fauna of the study period could be conveniently grouped into 11 taxa (Table 2). Fig. (2) shows the arrangement of these taxa distributed among the months according to CA and AHC methods to data of activity-density of soil fauna (Table 2). 70% of the total variance is associated with the first (horizontal) axis and 9% with the second (vertical) one. Nov. 1990 sampling is separated along the first axis at one end of the ordination graph with higher number of *Messor* sp. At the other end, three groups are separated from each other along the second axis. The first group consists of 8 months. These months are similar to each other in their faunal composition due to the presence of 3 species. These species are *Coleophora euryaula*, *Monomorium* sp. and Mesostena *angulatus*. Jan. 1991 is characterized by *Forficula* sp., *Scelosodis castaneus* and *Araneus* sp. Sep. 1990 sampling is characterized by *Gryllus burdigalensis*, *Camponotus* sp. and *Diorhabda elongata sublineata*.

Arrangement of taxa according to dominance and/or importance is based on different criteria which are shown in Table (3). Five species are considered to be the most dominant or important taxa. Arrangement of these species according to average activity-density (AD),absolute frequency (AF) and absolute and relative importance values (AIV and RIV) in descending order is: *Monomorium* sp., *Messor* sp., *Araneus* sp., *Gryllus burdigalensis* and *Camponotus* sp. This arrangement is slightly different when based on fresh weight biomass (BM) criterion. In this case, the arrangement of the dominant and/or important taxa in descending order is: *Araneus* sp., *Monomorium* sp., *Messor* sp., *Gryllus burdigalensis*, and *Camponotus* sp. and *Coleophora euryaula*. Arrangement of the recorded taxa of soil fauna of the present study according to AIV and RIV is shown in Fig.(3).

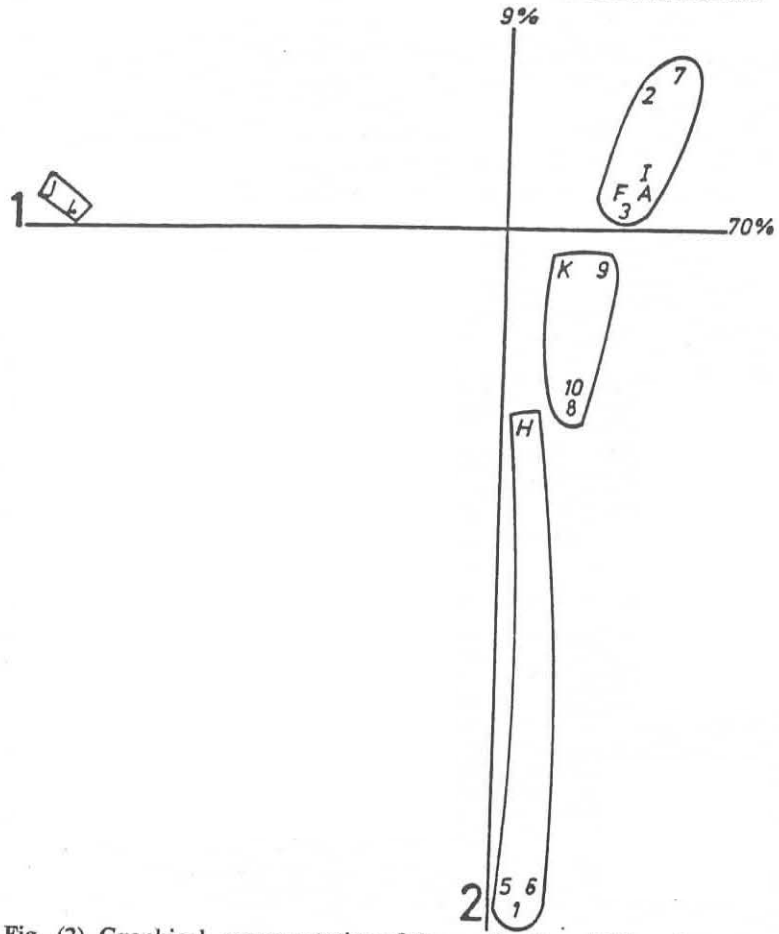

Fig. (2) Graphical representation of the application of CA and AHC methods to data of Table (2). Months, letters A-K: A, November 89; December; C, January 90; D, April; A, May; F, June; G, July; H, September; I, October; J, November; K, January 91. Taxa, numbers 1-10: 1, Gryllus burdigalensis; 2, Coleophora euryaula; 3, Monomorium sp.; 4, Messor sp.; 5, Camponotus sp.; 6, Diorhabda elongata subljneata; 7, Mesostena angulatus; 8, Scelosodis castaneus; 9, Araneus sp.; 10, Forficula sp. A superimposed B, C, D, E; F superimposed G; 8 superimposed 10; 1 superimposed 5, 6.

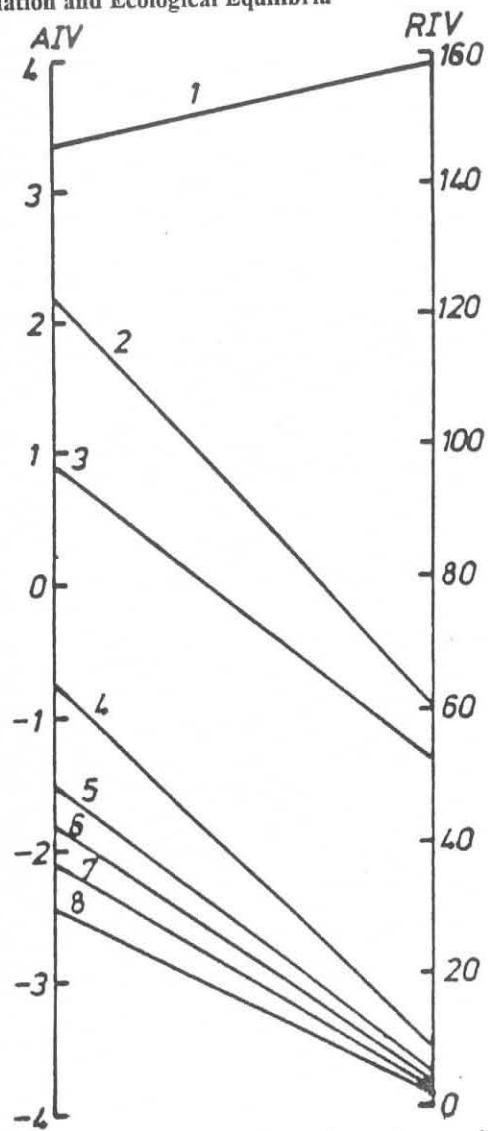

Fig. (3) Position of taxa on the absolute importance value (AIV) and relative importance value (RIV) scales. 1, Monomorium sp.; 2, Messor sp.; 3, Araneus sp.; 4, G. burdigalensis; 5, Camponotus sp.; 6, C. euryaula; 7, Forficula sp., M. angulatus and S. castaneus; 8, Diorhabda elongata sublineata.

Table (2) Monthly variation of the average activity-density (no. of indiv./ trap of species and/or higher taxa of soil fauna during the period of the present study between Nov. 1989 and Jan. 1991 at Dihmit farm area. (E, ecological function; H, herbivore; D, detritivores; C, carnivore)

		Nov .89	Dec.	Jan. 90	Apr.	May	June.	July	Sep.	Oct.	Nov.	Jan. 91
Taxa	E											
Odonata	C											0.1
Damsel fly*												
Gryllidae	D								0.3			
Gryllus burdigalensis												0.1
Dermaptera	C											
Forficula sp.												
Lepitopdera	H						0.1					
Coleophora euryaula												
Formicidae	D								0.2			
Camponotus sp.	H						0.3	0.2	0.9		7.0	0.3
Messor sp.	H	0.3	2.9	2.0	0.6	1.8	7.0	5.0	4.1	4.1	0.8	1.7
Monomorium sp.												
Coleptera												
Chrysomelidae	H								0.1			
Diorhabda elongate sublineata												
Tenebrionidae	D									0.1		
Mesostena angulatus	D											0.1
Scelosodis castaneus												
Araniae	C						0.1			0.1		0.3
Araneus sp.												
Total		0.3	2.9	2.	0.6	1.8	7.5	5.2	5.6	4.3	7.8	2.6
Herbivores		0.3	2.9	2.0	0.6	1.8	7.4	5.2	5.3	4.1	7.8	2.1
Detritivores		-	-	-	-	-	-	-	0.2	0.1	-	0.1
Carnivores		-	-	-	-	-	0.1	-	0.1	0.1	-	0.4
		0	0	0	0	0	0.3	0.17	0.88	0.16	0.32	1.17

*)fortuitous catch

The monthly variation in percentage of herbivorea, detritivores, and carnivores are shown in Table (2).Herbivores were present during all the sampling period ,while detritivores and carnivores appeared in very small numbers only at the end of the sampling period. Also, at the end of the sampling period, numbers of herbivores were markedly reduced.

Table (3) Average activity- density (AD) as no. of indiv./ trap and biomass (BM) in mgm, absolute frequency (AF) and absolute and relative importance values (AIV and RIV) of species and /or higher taxa collected during the present study.

Taxa	AD	BM	AF	AIV	RIV
Damsel fly*	0.01	0.01	0.91	-4.04	1.89
Gryllus burdigalensis	0.03	2.7	2.73	-0.66	8.71
Forficula sp.	0.01	0.9	0.91	-2.09	2.90
Coleophora	0.01	1.8	0.91	-1.79	3.92
euryaula	0.02	0.9	1.82	-1.48	4.79
Camponotus sp.	0.79	19.5	10.00	2.19	59.31
Messor sp.	3.17	22.4	30.91	3.34	158.05
Monomorium sp.	0.01	0.4	0.91	-2.44	2.33
Diorhabda elongata	0.01	0.9	0.91	-2.09	2.90
Mesostena	0.01	0.9	0.91	-2.09	2.9
angulatus	0.05	37.8	4.55	0.93	52.26
Scelosodis castaneus					
Araneus sp.					

*)fortuitous catch

Although the number of main taxa recorded during the present study is 10 taxa (excluding Odonata),a certain pattern emerges. The first 5 sampling months contain a single herbivore species (*Monomorium* sp.).Number of species increased and reached a maximum of 6 species at the end of the sampling period. As a result, Shannon-Wiener index of diversity had zero values during the first 5 sampling months and reached its maximum value (1.17)at the end of the sampling period (Table 2).

DISCUSSION

Soil animals of the present study are mainly Gryllidae, Dermaptera, Lepidoptera, Formicidae, Coleoptera, and Aaranidae. Coleoptera consists of Chrysomelidae (one species)and Tenebrionidae (two species).Formicidae represent about 96% of the total trap catches while the other five groups are represented by only 4%. These results are quite different from those obtained by MIKHAIL and SOBHY (1992 a and b)for Wadi Allaqi and Wadi Quleib. These two wadis are 120 km in a SE direction from Dihmit farm In these two wadis, Formicidae represent 69 and 80% of the total trap catches for Wadi Allaqi and Wadi Quleib respectively. Thus changes in the total activity-density of herbivorous species are manifested by activity density of Formicidae, especially *Monomorium* sp. and *Messor* sp. *Camponotus* sp. .,which was present only in Dihmit farm was completely absent from the two wadis (MTKHAIL and SOBHY, 1992 a and b).

Herbivores, detritivores and carnivores are three major trophic groups that can be identified in the surface active fauna of the hot desert(WALLWORK, 1982). Several studies concerned with these three groups are well documented in desert ecology text books (CRAWFORD, 1981 ;WALLWORK, 1982; LOUW and SEELY, 1982). Recently, GHABBOUR(1991) pointed out the importance of studying these groups in various ecosystems and under various management (or land use) practices in relation to potential for pest outbreaks when a natural ecosystem (usually in a desert)is converted to agriculture (land reclamation and creation of agro-ecosystems).In her review, HUNTLY (1991),mentioned that herbivores had little impact on the dominant plant species within nonsuccessional (equilibrium) terrestrial communities, because the dominant herbivore populations ordinarily are limited by their predators, not by their food supply. These comments refer to macro herbivores but they seem to apply equally well to micro herbivores among the soil fauna, as was suggested by GHABBOUR (1984).

In the present study, the three ant species were considered as: *Monomorium* and *Messor* herbivores, and *Camponotus* a detritivores, according to WILSON (1971).All tenebrionid species were considered detritivores, although some of them may occasionally eat living plant parts or attack living small animals, especially as eggs or larvae. Human

induced perturbations in the balance between trophic groups of soil fauna causes an increase in herbivores and a decrease in carnivores natural enemies (GHABBOUR, 1991).This will appear in the area of the present study (Table 2). HUNTLY (1991) added that in very unproductive habitats (early stages of area of the present study),resident herbivores are not supported by the low phytomass, and plants are resources limited (single herbivore species in early samplings of the present study). She added that as productivity increases, herbivores populations can be supported and the vegetation becomes limited by herbivore (appearance of several species at late stages of the sampling of the study area) and further increases in productivity allow carnivores to persist . In other words more prey types provide more niches for predators (GASTON et al., 1992). TILMAN and EL-HADDI (1992) suggested that incipient agriculture reduces biodiversity in case of grasslands but the present study shows that this may be also the case in desert ecosystems, even at the hyper-arid end of the scale, as long as irrigation water is regularly provided, although here the diversity index increased gradually with time during the first year, as the farm was started in a bare and lifeless desert. It will be important to watch for the development of biodiversity here in the later stages of land reclamation.

The three sites that were studied in the South Eastern desert of Egypt, Wadi Allaqi, Wadi Quleib and Dihmit farm (Mikhail AND SOBHY 1992 a and b) and the area of the present study can now be compared. Application of CA and AHC methods to average activity-density of species and/or higher taxa found in the three areas (Table 4) is shown in Fig. (4). 81% of the total variance is associated with the first (horizontal) axis and 19% with the second (vertical)one. The first axis represents the degree of human induced perturbation. The maximum is at the left hand side of the ordination graph (Dihmit farm) and the minimum is at the right hand side (Wadi Allaqi and Wadi Quleib). The second axis separates Wadi Allaqi (several years of inundation by waters of Lake Nasser) and Wadi Quleib (which was not inundated). Each site has its characteristic taxa. Dihmit farm has large numbers of herbivorous species and has disequilibrium between the 3 trophic groups. On the other hand, each of Wadi Allaqi and Wadi Quleib attain some equilibrium between these 3 groups.

The proportions of herbivores (potential agricultural pests) in Dihmit farm and each of Wadi Allaqi and Wadi Quleib are shown in Table (4).

x^2 test reveals that there is a highly significant difference at $p<0.001$ between numbers of the trophic groups. In this case, the difference can be safely regarded as "real" rather than accidental.

Table (4) Average activity-density of soil fauna in Dihmit, Wadi Allaqi (MIKHAIL & SOBHY 1992 a) and Wedi Quleib (MIKHAIL & SOBHY 1992 b). Figures are multiplied by 100. E=ecological function.

Taxa	E	Dihmit	Allaqi	Qulei b
Thysanura	D	-	1	4.2
Gryllidae, Gryllus burdigalensis	D	3	2	0.5
Mantidate	C	-	0.4	-
Dermaptera, Forficula sp.	C	1	-	-
Lepidoptera, Coleophora euryaula	H	1	8	18
Crambus sp.	H	-	2	5
Pompilidae	C	-	0.4	-
Formicidae, Camponotus sp.	D	2	-	-
Messor sp.	H	79	8	19
Monomorium sp.	H	317	136	467
Coleoptera				
Buprestidae, Julodes fembriata	D	-	3	13
Chrysomelidae, D. elongata	H	1	2	3
Tenebrionidae,				
Adesmia bicarinata	D	-	14	20
Mesostena angulatus	D	1	5	7
Pimelia supquadrata	D	-	4	8
Scelosodis castaneus	D	1	9	23
Trachyderma philistina	D	-	4	14
Scorpions	C	-	4	1
Aranidae, Araneus sp.	C	5	4	2
Paradosa sp.	C	-	4	2
Herbivores	%	96	74	84
Detritivores	%	2	19	14
Carnivores	%	2	7	2

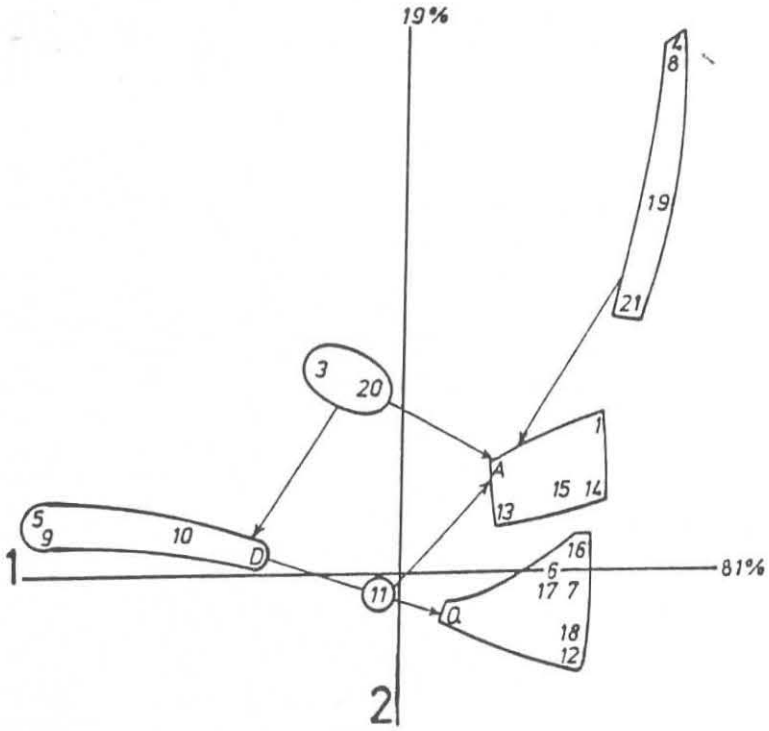

Fig. (4) Graphical representation of the application of CA and AHC methods to data of Table (4). Sites, letters: A, Wadi Allaqi; Q, Wadi Quleib; D, Dihmit farm. Taxa, numbers 1-21: 1, Thysanura; 3, G.burdigalensis; 4, Mantidae; 5, Forficula sp.; 6, C. euyarula; 7, Crambus sp.; 8, Pompilidae; 9, Camponotus sp.; 10, Messor sp.; 11, Monomorium sp.; 12, Julodis fembriata; 13, Diorhabda elongata; 14, Adesmia bicarinata; 15, M. angulatus; 16, Pimelia subquadrata; 17, S. castaneus; 18, Trachyderma philistina; 19, scorpions; 20, Araneus sp.; 21, Paradosa sp.

Intra-habitat diversity (alpha diversity) and inter-habitats diversity (beta diversity) were calculated as described by CANCELA DA FONSECA (1991). All of these diversities were calculated with Shannon-Wiener index of diversity (DESHMUKH, 1986). Generally, intra-habitat diversity (alpha) is lower in Dihmit than that in each of Wadi Allaqi and Wadi Quleib except in the case of intra-habitat diversity of herbivores (Table 5). As a result, inter-habitat diversity (beta diversity) is higher in Dihmit for detritivores and carnivores and is lower for herbivores (Table 5). Beta diversity is considered to be species rates of change (MAGURRAN, 1988) or turnover (WHITTAKER, 1975; GASTON et al., 1992). Thus, the degree of species rates of change or turnover of herbivores in Dihmit is in its minimum value when compared with the other two sites. Habitat destruction associated with incipient agriculture as well as environmental disturbance cause the loss of biodiversity in grasslands (TILMAN and El-HADDI, 1992). In the case of Dihmit farm, we have incipient agriculture in a lifeless desert as the sole factor which controls the process of building up of biodiversity of the different functional groups of soil fauna, which began with herbivores (potential pests) and developed into an assemblage of the 3 main functional groups with the appearance of detritivores and carnivores. Further monitoring of these ecological equilibria is needed to watch for pest irruptions as the agroecosystem reaches stability.

It was found that a few species would be very abundant, some would have medium abundance, while most would be represented by only a few individuals. This observation led to the development of species abundance models (WHITTAKER, 1975; SOUTHWOOD, 1978; MAGURRAN, 1988). Species ranking curves can used as simplified versions of such models as shown in fig. (5). Field data have shown that the geometric series pattern of species abundance is found primarily in species poor (and often harsh) environmental or in the very early stages of succession (WHITTAKER, 1975; MAGURRAN, 1988). As succession proceeds, or as conditions ameliorate, species abundance patterns grade into those of log series (MAGURREN, 1988). The line representing Dihmit (Fig.5) is very steep when compared with those of Wadi Allaqi and of Wadi Quleib. In this case soil fauna of Dihmit farm are considered to follow the geometric series pattern. Thus, one say that at early stages of desertagriculture, soil animals are under severe environmental conditions which may lead to the poverty of soil taxa other than herbivores, and this is clear in Fig. (6) which shows that carnivores appeared in the 8^{th} month and were followed by detritivores only in the 11^{th} month after start of

Table (5) Shannon-wiener index of diversity of total activity-density of soil fauna and activity-density of each of herbivores, detritivores and carnivores in Dihmit, Wadi Allaqi and Wadi Quleib.

	Dihmit	Wadi Allaqi	Wadi Quleib
Total soil fauna			
alpha diversity	0.725	1.551	1.061
beta diversity	1.551	0.725	1.060
Herbivores			
alpha diversity	0.573	0.536	0.373
beta diversity	0.901	0.963	1.380
Detritivores			
alpha diversity	1.041	1.709	1.751
beta diversity	1.738	1.059	1.030
Carnivores			
alpha diversity	0.796	1.528	1.322
beta diversity	1.940	1.010	1.168

sampling but still in extremely low numbers. This is in contrast with the case of Wadi Allaqi and Wadi Quleib where herbivores decreased gradually while carnivores and detritivores maintained their densities during the entire sampling period of 17 months (MIKHAIL and SOBHY, 1992 a and b). The difference between the Dihmit agro-ecosystem and the grazing systems of Wadi Allaqi and Wadi Quleib in this connection may be due to the fact that there is constant irrigation in the former with gradual increase in plant biomass, while the two desert ecosystems enjoyed only one rain event before sampling started and soil moisture gradually decreased as well as the green plant biomass.

Fig. (7) shows that number of species recorded in the site is not yet exhaustive. This will suggest the irruption of potential agricultural pests is more probable with the reclamation of such desert areas to be agro-ecosystem and they need continuous monitoring because they are still immature and have not reached ecological equilibrium.

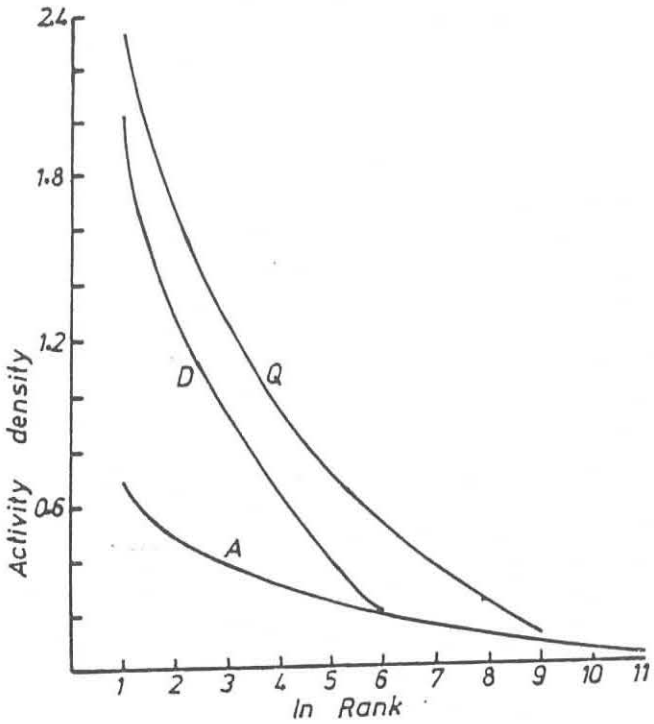

Fig. (5) Species ranking curve of soil fauna of each of Wadi Allaqi (A), Wadi Quleib (Q) and Dihmit farm (D).

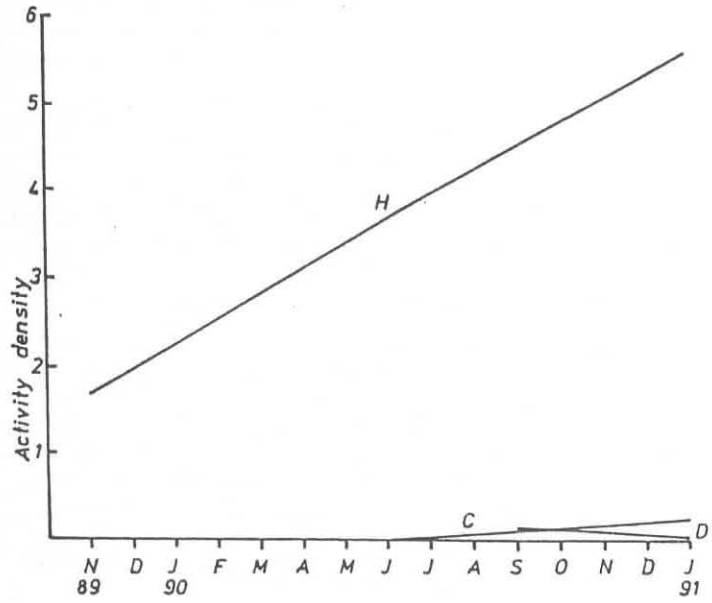

Fig. (6) Trend-line analysis of herbivores (H), detritivores (D) and carnvores (C) at Dihmit farm.

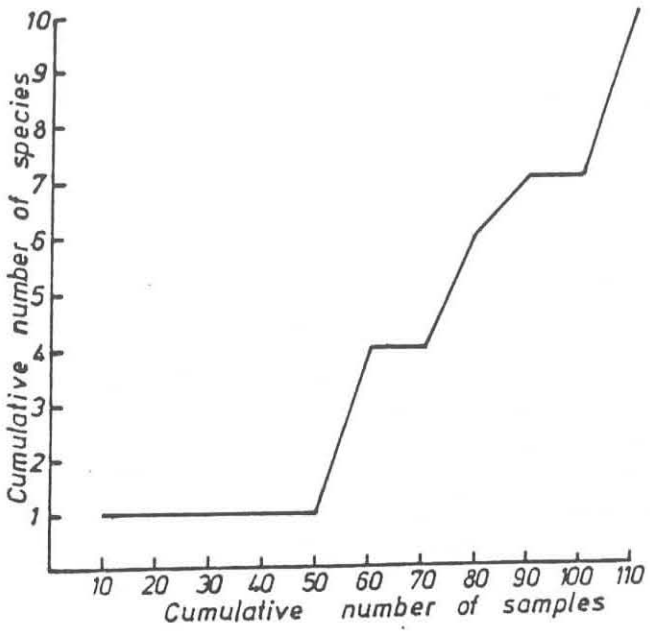

Fig. (7) **Cumulative number of species of soil fauna recorded at Dihmit during the period of sampling in relation to the cumulative number of samples showing "J" type of curve.**

ACKNOWLEDGMENTS

This research was carried out within the framework of the project "Sustainable Development of Wadi Allaqi" sponsored by the University of Assiut. Faculty of Science in Aswan, and funded by the United Nations Environment Program, and directed by Prof. A. Esmat Belal, Faculty of Science in Aswan. Sincerest thanks are due to these organizations and the Director and staff of the project. Thanks are also due to Prof. S. I. Ghabbour, who kindly revised the manuscript. Thanks are also due to Dr. M. Badr and Dr. F. H. Nigm, Plant Protection Research Institute, Agriculture Research Center, and Mrs. N. Samy, Assistant Lecturer, Dept. of Entomology, Cairo University, for their kind help in the identification of soil fauna species collected during the present study. Thanks are also extended to AHDLA personnel for kind permission to take samples from the Dihmit farm.

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